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Diamond Drive .. 4 Lane or 3 Lane? .. a TRANSIMS Viewpoint

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Diamond Drive . . 4 Lane or 3 Lane? . . a TRANSIMS Viewpoint

Ed Van Eeckhout, LaRon Smith, and Kriste Henson

I. Introduction

The Facilities and Waste Operations Division (FWO) requested that the Decision Applications Division TRANSIMS team evaluate the proposed conversion of Diamond Drive on Laboratory property to three lanes (1 lane in each direction with left turn lanes) instead of the current four lanes (2 lanes in each direction). This conversion is to address safety issues caused by poor visibility for left turns from Diamond Drive onto Eniwetok and Sigma (difficulty in seeing vehicles "shooting the gap" along Diamond Drive on the right) and by the current lane widths being non-standard (too narrow). Widening the road was not considered an option because of the expected cost and unavailable funds.

For this analysis, the following situations were evaluated: 4-lane versus 3-lane, morning and evening peaks; merge north versus merge south of Diamond/Jemez for the proposed 3-lane case, morning peak; "sequential signal phases" versus current 4-lane signal timings; and potential uncertainties of up to 20% in the morning peak traffic.

The data used to perform this analysis included a satellite orthophoto taken in July of 2000 (used to establish the network: Diamond Drive on Laboratory property and portions of the adjacent feeder roads), design drawings provided by FWO, turncount data taken in December 1999 at the three signal intersections (Jemez, Eniwetok, and Sigma) and at Diamond and Pajarito, and signal timing data provided by FWO and the optimization analysis performed by Bohannan-Huston. We used the TRANSIMS (Transportation Analysis and Simulation System) microsimulation module to simulate the performance of the various options and to generate results for the analyses.

II. Conclusions

- The results were quite dependent on the simulated signal timings.
- The 3-lane option would work, on the average, about the same as the current 4-lane situation (in terms of travel time through the system).
- For the 3-lane option a few travelers would experience a 25-50% increase in travel time over the average travel time of 3.5 – 4 minutes.
- The 3-lane option will place the morning traffic at close to its maximum throughput. Increases in traffic volumes could be expected to degrade the system.
- There is a distinct, dramatic advantage to merging south rather than north of the Diamond/Jemez intersection in the 3-lane option.
- The "sequential signal phases" 4-lane option may be quite viable, but signal timings and phase splits need to be optimized.
- Although the 3-lane option could eliminate the poor visibility problem, there may be other safety issues arising from aggressive merging, sudden decelerations at the merge, and blocking incidents.

III. Recommendations

- If the 3-lane option is implemented, it should be executed in a manner that would allow a return to the 4-lane if necessary.

IV. The Diamond Drive Network

Fig. 1. Network overlay on background satellite image of main laboratory area.

Figure 1 shows the network for this study. We created the network by overlaying roads and parking lots on a satellite orthophoto taken in June 2000 (provided us courtesy NIS-2 [copyright, Space Imaging, 2000]). This network represents the roads that vehicles travel in the simulation. In addition, we specified the lanes on each road and the allowed turning movements through all intersections. FWO provided drawings with specific lane configurations. Additionally, three signals (in red) are shown where traffic must obey timing constraints. The other intersections have either stop/yield signs or no traffic control as appropriate. Because the study's primary purpose was to understand the effect of Diamond Drive alternatives on Laboratory property, we did not model road features and intersections beyond the adjacent Diamond Drive feeders. Thus interactions with other Laboratory or Los Alamos county roadway signals or alternatives were not part of this study.

We created twelve "parking lots" where vehicles would begin and end their trips (they are located at the end of each potential route and are numbered in Fig. 1). Normally, TRANSIMS uses "activity" locations, places where travelers start and end various tasks, but for the intent of this particular study, that TRANSIMS feature wasn't used. Instead, we began with the travelers and their associated vehicles (one traveler per vehicle) at each parking lot.

For the 4-lane configuration, we modeled the 2 lanes in each direction the full length of Diamond Drive from Jemez Road to Pajarito Road. Appropriate turn pocket lanes were included at the Jemez Road intersection. For the 3-lane configuration, we modeled a single lane in each direction on Diamond Drive and added left turn pockets of length approximately 49 m at the Eniwetok and Sigma intersections and at the intersections for "parking lots" 4 and 5. A merge distance of length 123 m was included on the south side of the Jemez Road intersection to allow the two southbound lanes to merge to one. We also increased the northbound lanes from one to two lanes 123 m south of the Jemez Road intersection. For the case where the southbound merge would occur north of the Jemez Road intersection, we forced the right lane traffic crossing the Los Alamos Canyon bridge to turn right onto West Jemez Road whereas the left lane traffic would continue straight. This is about 128 m before the Jemez Road intersection. Traffic going to East Jemez Road would then use the left turn pocket on the roadway segment from the bridge to the intersection.

V. Traffic Signals

We modeled traffic signals at the Diamond Drive intersections with Jemez Road, Eniwetok Drive, and Sigma Drive. Although these signals are activated, we modeled them as pre-timed signals because for the peak-period traffic volumes they probably run through the full phases anyway. We experimented with different signal cycle lengths and phase splits as we attempted to baseline the existing conditions. These results as well as the formal study results indicated a high sensitivity to the signal cycle lengths and phasings. For the study results presented in this report, Danny Grijalva (FWO) provided the phase splits and timings for the current 4-lane signal setup, and Bohannan-Huston (a FWO consulting firm) provided proposed optimal timings for the 3-lane configuration.

Figure 2 shows the timings and splits for the current morning 140-second cycles and the proposed 120-second cycles. Table I shows an example phase timing table used in the simulations. The afternoon simulations for the current 4-lane configuration used a 115-second cycle timing plan. To improve the southbound traffic flow on Diamond Drive during the morning, the green phase for southbound traffic at the Eniwetok and Sigma intersections were timed to begin 30 seconds after the the green phase for southbound traffic at the Jemez Road intersection. The direction of this 30-second offset was reversed for the afternoon simulations. We did not model the effect of pedestrian demand on the "walk" signals.

In the simulation the 140-second cycle phases at Eniwetok and Sigma are not quite a correct representation of the current phases in the real system. In the real system, phase 2, rather than permitting left turns from both directions on Diamond, permits both through and left turns for only the southbound traffic for a short duration before permitting through and unprotected left turns from both directions. There also is a short phase following phase 3 that permits both through and left turns for only the northbound traffic. We believe that this discrepancy in the simulation does not affect the overall conclusions of the study. Furthermore, after observing the 3-lane results with 120-second cycle signal plans, we also ran the 4-lane configuration with 120-second cycle signal plans to more easily assess the effect of changing from 4 lanes to 3 lanes without introducing other factors such as different signal timings.

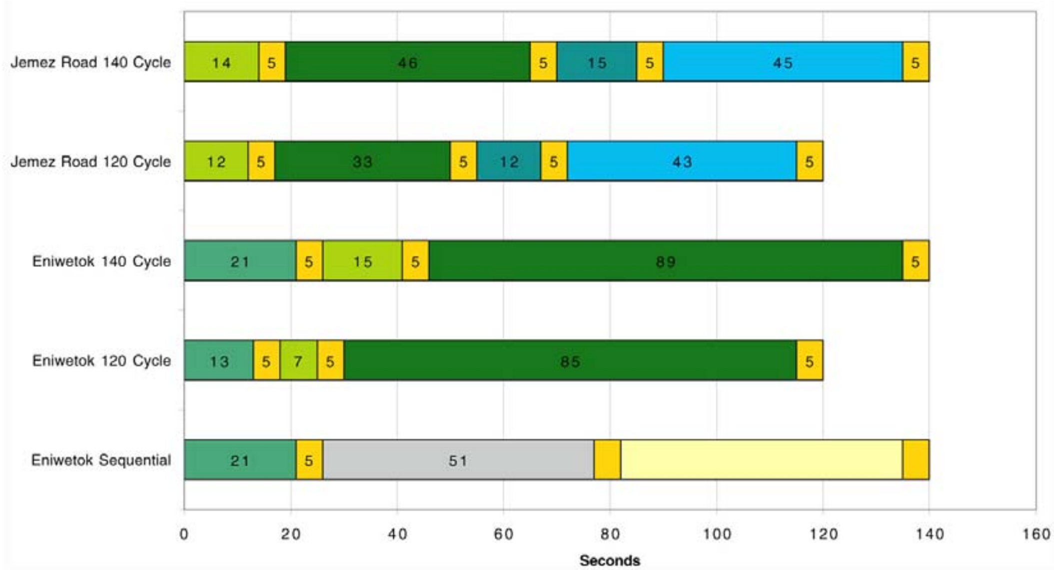


Fig. 2. Example AM signal Timings and Phases.

(Phase split times are indicated in Fig. 2. Each phase is separated by a 4 second amber plus 1 second red clear. For Jemez Road, the first phase permits left turns from Diamond Drive, the second phase permits through traffic and unprotected left turns from Diamond Drive, the third phase permits through and left turn traffic from West Jemez Road, and the fourth phase permits through and left turn traffic from East Jemez Road. For Eniwetok, and Sigma, the first phase permits cross traffic, the second phase permits left turns from Diamond Drive, and the third phase permits through traffic and unprotected left turns from Diamond Drive. For the "Sequential Signal" simulation at Eniwetok and Sigma, the first phase permits cross traffic, the second phase permits through and left turn traffic left turns for southbound traffic on Diamond Drive, and the third phase permits through and left turn traffic left turns for northbound traffic on Diamond Drive.)

Table I.

Example Phase Timing Table.

Bohannan am timings . . 120 sec									
PLAN	PHASE	NEXTPHASES	GREENMIN	GREENMAX	GREENEXT	YELLOW	REDCLEAR	GROUPFIRST	NOTES
1	1	2	13	0	0	4	1	1	NONE
1	2	3	7	0	0	4	1	0	NONE
1	3	1	85	0	0	4	1	0	NONE
2	1	2	13	0	0	4	1	1	NONE
2	2	3	7	0	0	4	1	0	NONE
2	3	1	85	0	0	4	1	0	NONE
3	1	2	12	0	0	4	1	1	NONE
3	2	3	33	0	0	4	1	0	NONE
3	3	4	12	0	0	4	1	0	NONE
3	4	1	43	0	0	4	1	0	NONE

VI. Traffic Volumes

TRANSIMS requires traveler plans (specific routes) and vehicle information as input for the microsimulation. For this simple network we created traveler origin-destination tables to match turn counts obtained during the month of December 1999 for the intersections in question. The trips from the origin parking lot to the destination parking lot are shown in Table II for the period 7 to 8 am and Table III for 4 to 5 pm (the peak traffic hours). Again, for this simple network it was easy to generate the appropriate route plan for each traveler. We did not simulate travelers for which the origin-destination value in the tables was less than five, and hence we simulated 3799 vehicles in the morning and 2928 vehicles in the afternoon.

For most study analyses, we generated the traveler start times randomly from a uniform distribution throughout the hour simulated. Because our network did not extend to the signals at Diamond and Trinity or Diamond and West Road, we also did not model or simulate any vehicle "platoon" effects or traffic surges coming from North Diamond.

The most significant traffic volumes between the origins and destinations are highlighted in yellow in the tables. Although we collected information on every traveler, for this study we concentrated on the performance of vehicles taking the most heavily traveled paths that extended the full length of Diamond Drive from the Jemez Road intersection to Pajarito Road in either direction. For the morning we were interested in the travelers from East Jemez and North Diamond to East Pajarito (paths 1 to 10 and 2 to 10, respectively) and from East Pajarito to North Diamond and West Jemez (paths 10 to 2 and 10 to 3, respectively). [Note that these location descriptions are relative to the simulation network and not necessarily part of the real road name.]

For the afternoon studies, we were interested in the travelers from North Diamond to East Pajarito (path 2 to 10) and from East Pajarito to North Diamond and East Jemez (paths 10 to 2 and 10 to 1, respectively).

Table II.

Trips from one parking lot to the another from 7 am to 8 am in December 1999.

To . . **From** Parking Lot . .

	1	2	3	4	5	6	7	8	9	10	11	total
1	x	189	44	0	0	2	1	1	1	20	1	258
2	161	x	161	0	0	25	8	8	7	223	13	606
3	525	587	x	0	0	14	4	4	4	124	7	1270
4	8	15	1	x	0	0	0	0	0	6	0	29
5	23	44	2	0	x	0	0	0	0	17	1	88
6	44	83	4	0	0	x	0	0	0	27	2	161
7	12	23	1	0	0	0	x	0	0	42	2	81
8	23	43	2	0	0	0	0	x	0	26	2	96
9	36	67	4	0	0	0	0	0	x	19	1	126
10	201	376	20	0	0	13	9	10	15	x	120	764
11	28	53	3	0	0	2	1	1	2	265	x	356
total	1062	1480	243	0	0	56	23	24	29	768	150	3835

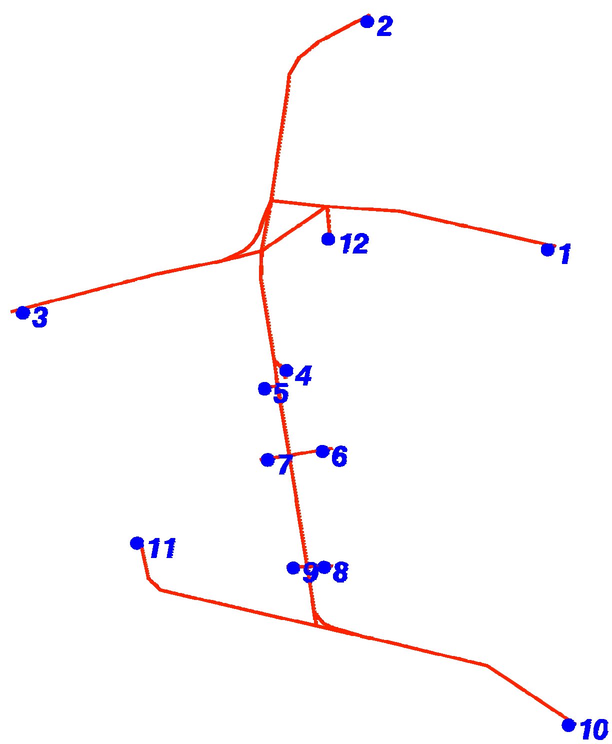
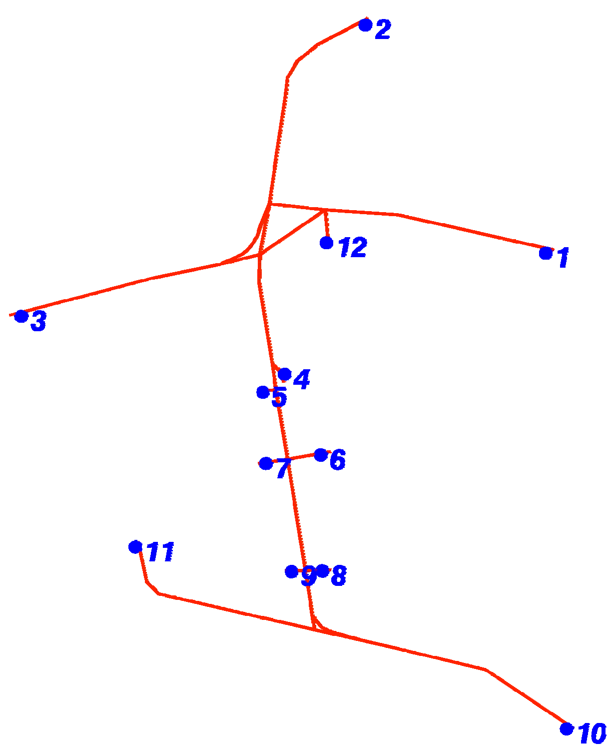


Table III.

Trips from one parking lot to the another from 4 pm to 5 pm in December 1999.

To . . **From** Parking Lot . .

	1	2	3	4	5	6	7	8	9	10	11	total
1	x	128	325	4	12	25	10	13	17	108	8	650
2	166	x	588	12	37	78	32	40	54	341	26	1374
3	30	124	x	1	4	7	3	4	5	33	3	213
4	0	0	0	x	0	0	0	0	0	0	0	0
5	0	0	0	0	x	0	0	0	0	0	0	0
6	2	18	2	0	0	x	0	0	0	10	1	32
7	0	1	0	0	0	0	x	0	0	9	1	11
8	1	8	1	0	0	0	0	x	0	11	1	21
9	1	8	1	0	0	0	0	0	x	16	1	26
10	18	197	20	17	50	16	18	15	13	x	185	548
11	1	16	2	1	4	1	1	1	1	60	x	89
total	219	500	938	35	106	127	64	73	90	587	226	2965



VII. TRANSIMS Simulations

The TRANSIMS microsimulation uses a cellular automata (CA) approach to traffic simulation. The lanes of the network are partitioned into cells of length 7.5 meters. A cell may or may not contain a vehicle. The vehicle positions are updated every second based on a few simple rules that have been shown to produce a reasonable representation of traffic. Complete documentation of the TRANSIMS microsimulation and other modules can be found on the TRANSIMS web site: http://transims.tsasa.lanl.gov. The site also contains additional papers and documents describing the theoretical development and basis for the microsimulation methods.

For this study, the roadway speed limits were all set at 35 mph (15.65 m/s), which TRANSIMS converts to two cells as the maximum number of cells that a vehicle may move each second. While this is close to 35 mph, we used a vehicle slowing down probability in the CA method that reduced the vehicle average velocity to about 30 mph in the absence of other vehicles, signals, or traffic signs. In contrast, if there is no vehicle in the two cells ahead of them, the majority of vehicles will accelerate to two cells per second (35 mph) in two seconds. While these CA features are not offsetting, they do have somewhat opposite effects in terms of the speed of moving vehicles through the network.

Although we did not calibrate the microsimulation performance to real traffic data taken on Diamond Drive, calibrations have been made in other studies that indicate that, from a statistical point of view, the CA does a fairly good job of representing real traffic. Our confidence in the results was strengthened after we baselined the existing 4-lane configuration using current signal timings. While there may be some questions about the absolute validity of the individual results, we believe that, when comparing the alternatives in this study, the TRANSIMS results provide a reasonable indication of what can be expected.

VIII. TRANSIMS Input and Output

A brief listing and description of the files that were generated for this study are included in Appendix A of this report.

For output we collected snapshot data (second-by-second information on the location of every vehicle), event data (specific changes that happen to each traveler as they execute their travel), link travel time summary data (summed travel time information for all the vehicles that have traversed a roadway segment in a given period), link density summary data (the number of vehicles on a particular roadway segment at a given time), and log files (a record of the TRANSIMS execution, including some summary information about the run). We used the snapshot data to produce and study second-by-second movies of the vehicles moving through the network. We extracted travel times for each traveler from the event data; this information is the primary measure of effectiveness used to evaluate the various alternatives. At this time we have not used the other output information in the analyses of this study.

Although we ran many more simulations, only those significant to the conclusions of this study are discussed in this report.

IX. Morning Simulation: 3-lane vs 4-lane, 140 sec (current) vs 120 sec (proposed) timings

We performed a series of simulations for comparing the various Diamond Drive alternatives. In this section we compare the results for 3 lanes (south side merge) and 4 lanes. We ran the 3-lane configuration with the proposed 120-second cycle signals and the 4-lane configuration with the current 140-second cycle signals. To eliminate confusion about whether the lane changes or the signal changes caused any differences, we also ran the 4-lane configuration with the 120-second cycle signals.

For the three simulations we compared the traveler travel times for the four paths: East Jemez and North Diamond to East Pajarito (paths 1 to 10 and 2 to 10, respectively) and from East Pajarito to North Diamond and West Jemez (paths 10 to 2 and 10 to 3, respectively). In this report we use several different displays to compare the results. Figure 3 shows the travel time distributions for the travelers from North Diamond to East Pajarito. In this figure, for each simulation the vehicle travel times to get from "parking lot" 2 to "parking lot" 10 have been plotted in the order from the fastest along the path through the network to the slowest. The fastest vehicle in one simulation is not the fastest in another simulation.

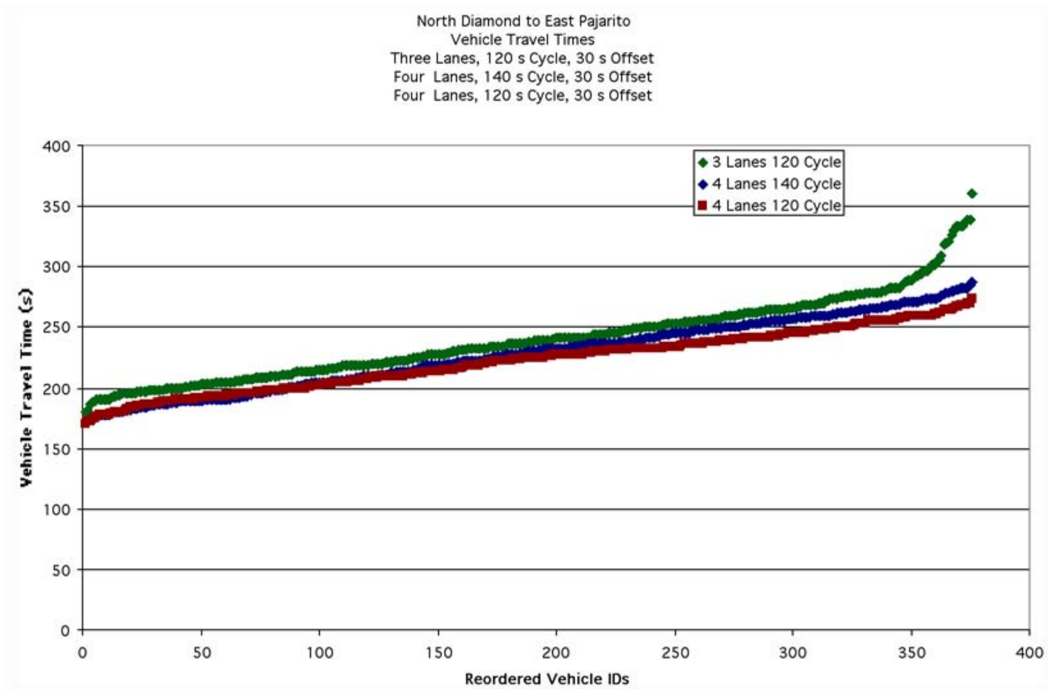


Fig. 3. Comparison of North-Diamond-to-East-Pajarito travel time distributions for 4-lane 140-second cycle, 4-lane 120-second cycle, and 3-lane 120-second cycle configurations.

For the 4-lane configuration the 120-second cycle signals show a slight improvement over the 140-second cycle signals. On the average the 3-lane configuration does not differ much from the 4-lane configuration, but there are some travelers on the tail of the distribution whose travel times are 25-50% greater than the average travel time. These people experiencing excessive delays are the ones expected to file complaints about the situation. These would not necessarily be the same travelers from day to day so a person taking this path during this peak period could expect to have days when he is delayed for no other reason than the change in lane configuration.

Figure 4 shows another way of displaying the results of these simulations. For this comparison we show the number of travelers whose travel times are in each 30-second interval. The shift of the 4-lane 120-second cycle to the lower travel times again indicates a slightly better performance than the 4-lane 140-

second cycle signals. For the 3-lane configuration the shift toward longer travel times is much more apparent, particularly for the travelers with long travel times on the upper end of the distribution.

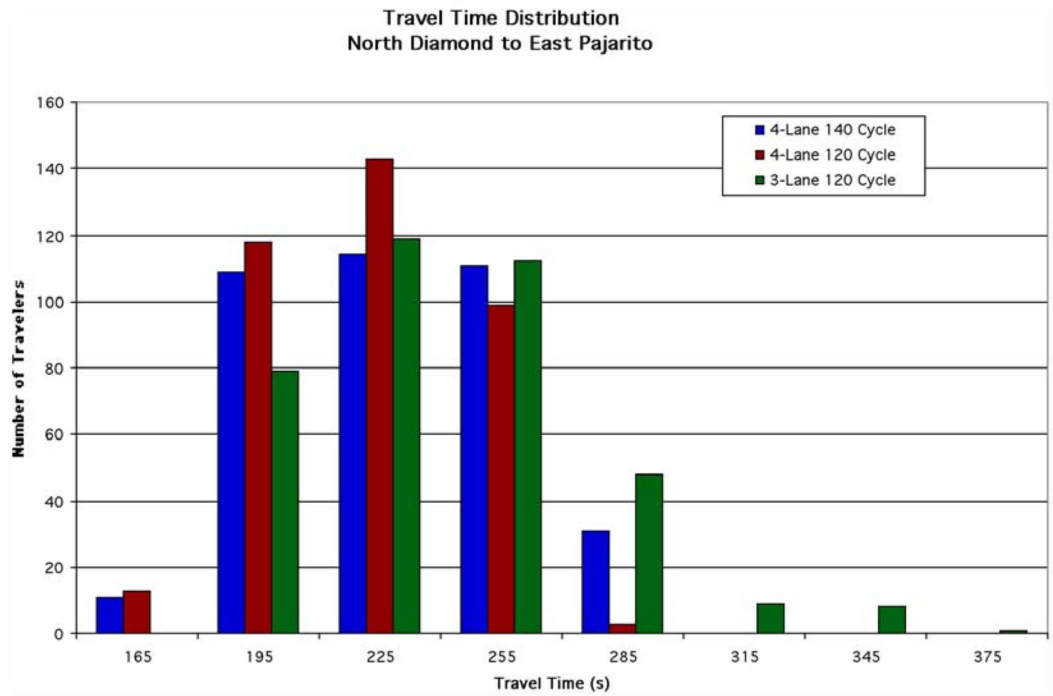


Fig. 4. 30-second histogram distributions of vehicle travel times from North Diamond to East Pajarito for 4-lane 140-second cycle, 4-lane 120-second cycle, and 3-lane 120-second cycle configurations.

We created displays similar to Figs. 3 and 4 for the other paths, but Fig. 5 encapsulates this information for the four heavily traveled paths. In this figure we show the mean and the 5, 25, 50, 75, and 95 percentiles for each travel time distribution for the four paths in each of simulated configurations. The second set of points from the left shows this information for the North Diamond to East Pajarito path that we compared in Figures 3 and 4. We see that the 4-lane 120-second cycle has a slightly lower mean and median than the 4-lane 140-second cycle and a slightly tighter distribution corresponding to that shown in Figure 4. The whole distribution for the 3-lane configuration is shifted to longer travel times and the average travel time is about 12 seconds slower than the 4-lane 140-second cycle case.

The travelers for the East Jemez to East Pajarito path have slightly longer travel times than those traveling from North Diamond even though the distance is slightly less, 2355 m versus 2385 m between the respective “parking lots.” The 4-lane 120-second cycle signals give about an average 25 second improvement for this path over the 140 second cycle signals. The 3-lane configuration loses about 10 seconds of this gain; however, for this path the high end of the distribution does not have the travelers with the much longer travel times observed in the North Diamond to East Pajarito path.

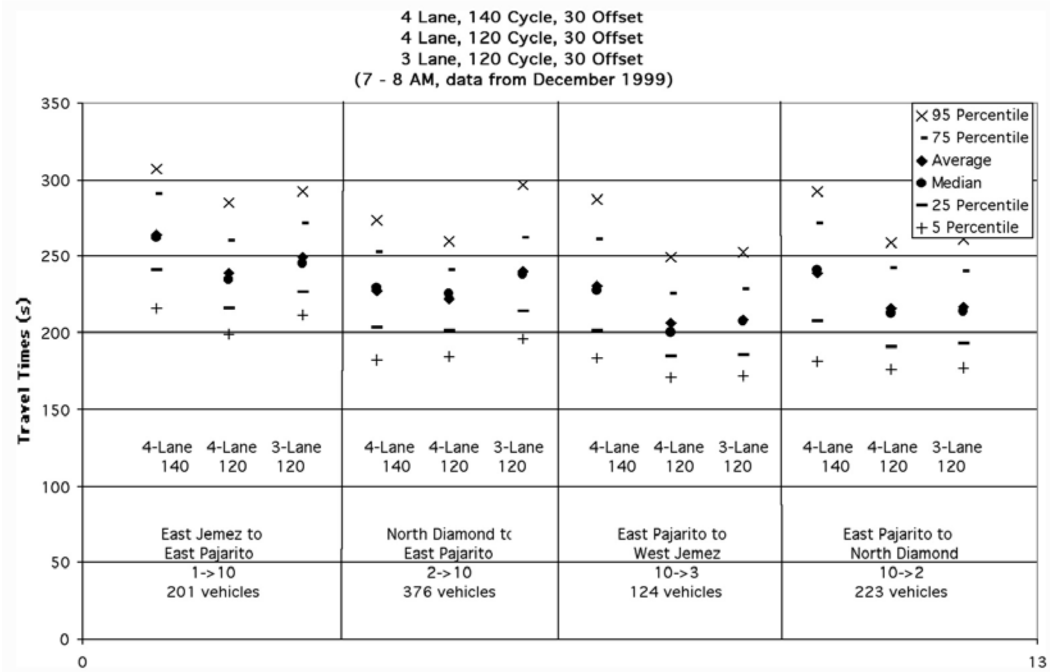


Fig. 5. Averages and percentiles of travel time distributions for the four heavily traveled Diamond Drive paths for 4-lane 140-second cycle, 4-lane 120-second cycle, and 3-lane 120-second cycle configurations.

For northbound traffic, East Pajarito to West Jemez and to North Diamond, the use of 120-second cycle signals provides more than 20 seconds improvement in average travel time, and for this signal setup, the 3-lane configuration has about the same performance as the current 4-lane configuration.

X. Morning Simulation: 4-lane, 140-second cycle signals, sequential phases

Figures 6 and 7 compare the North Diamond to East Pajarito travel time distributions for the current 4-lane configuration, the proposed 3-lane configuration, and a potential sequential signal phasing at the Eniwetok and Sigma intersections (see Fig. 2). The travel times for the sequential signals are about 30 seconds longer than for the normal signals. Some travelers at the distribution's high end for the sequential signals configuration experience longer travel times similar to those observed in the 3-lane configuration. We made no attempt to examine other signal phase splits that would optimize the use of sequential signals.

Figure 8 compares the travel time statistics of the four heavily traveled paths for these three configurations. The trends in the observations for the East Jemez to East Pajarito traffic are comparable to those for the North Diamond to East Pajarito traffic; the travel times for the sequential signals are around 20 seconds slower than for the normal signal phases. For the northbound traffic the sequential signals provide slightly faster travel times than the normal signal phases, but not as good as the 3-lane case (or 4-lane case) with 120-second cycle signals.

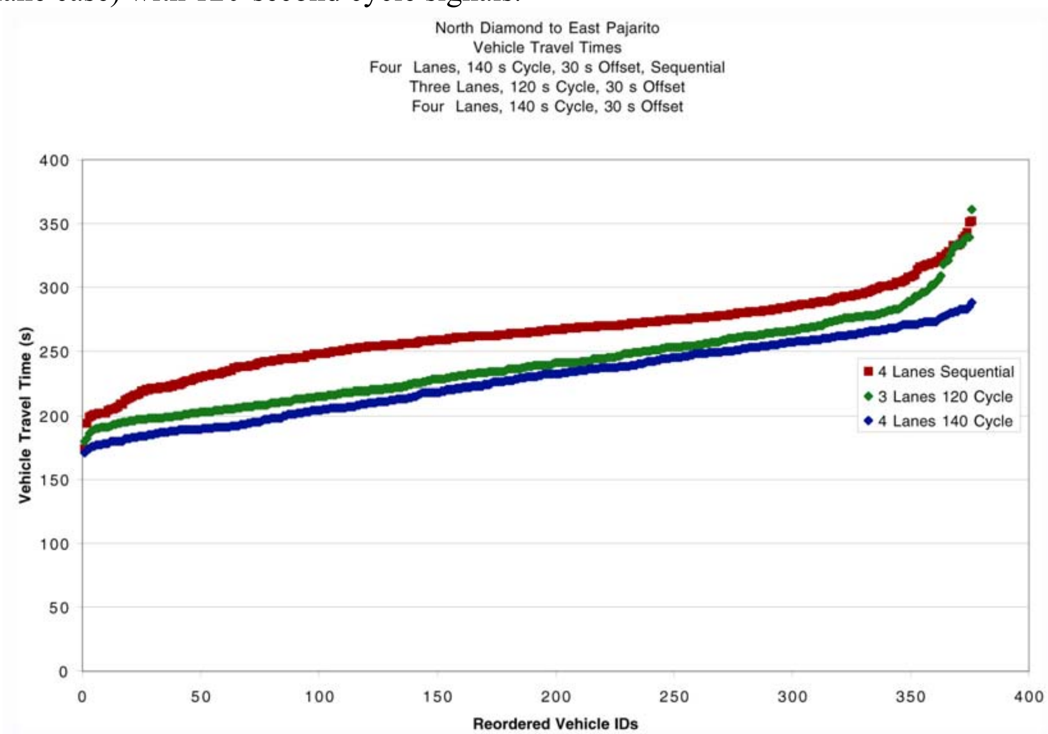


Fig. 6. Travel time distributions for the North Diamond-to-East-Pajarito path for the 4-lane sequential signal, the 4-lane 140-second cycle signal, and the 3-lane 120-second cycle signal configurations.

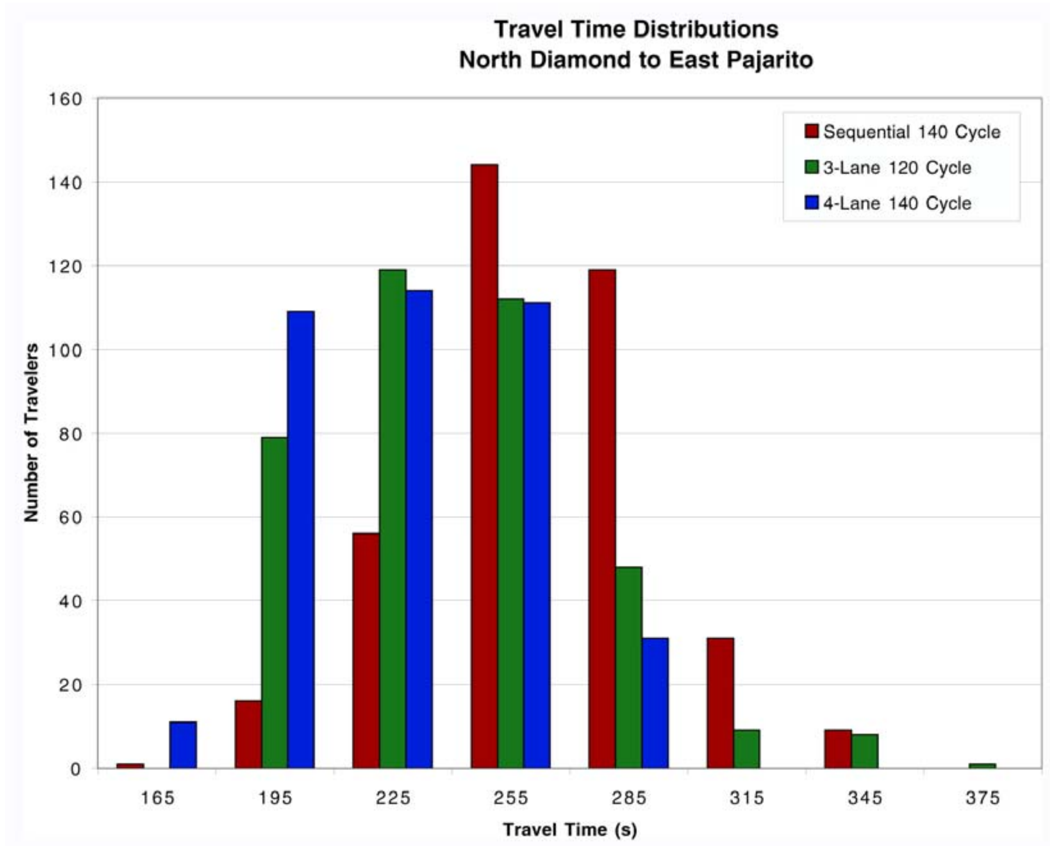


Fig. 7. 30-second histograms of vehicle travel times from North Diamond to East Pajarito for 4-lane sequential signals, 4-lane 140-second cycle, and 3-lane 120-second cycle configurations.

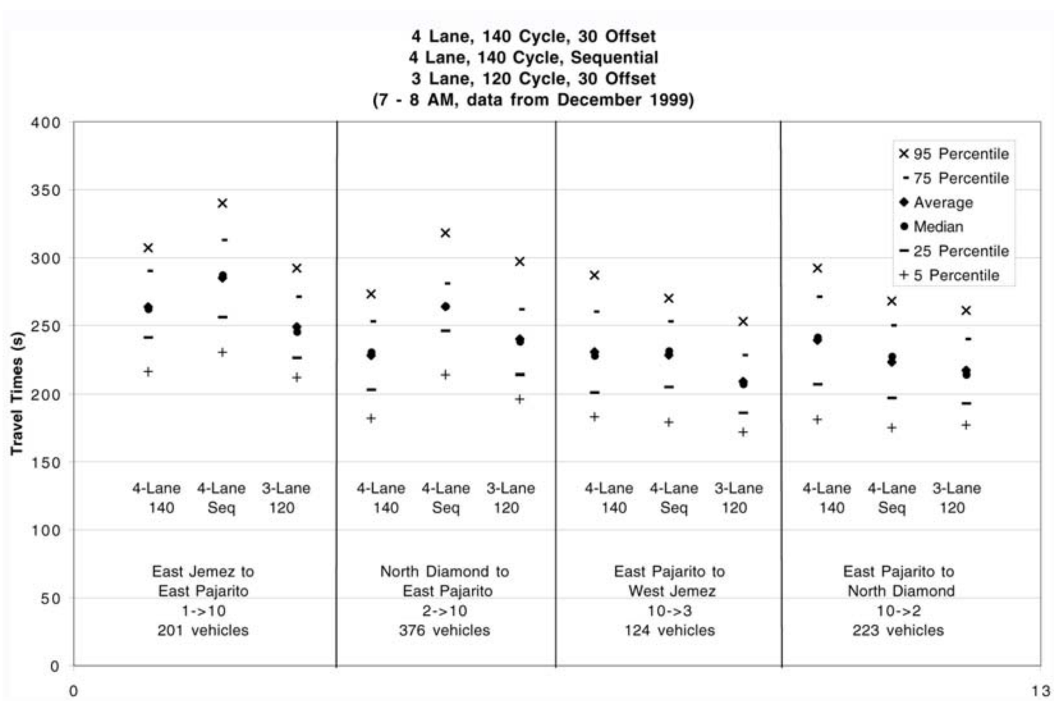


Fig. 8. Averages and percentiles of travel time distributions for the four heavily traveled Diamond Drive paths for 4-lane sequential signal, 4-lane 140-second cycle, and 3-lane 120-second cycle configurations.

XI. Morning Simulation: 3-Lane Configuration with Merge North of the Jemez Road Intersection

Another alternative was whether it would be better to merge from two southbound lanes to one southbound lane before the Diamond/Jemez intersection. For this case we forced the right lane traffic crossing the Los Alamos Canyon bridge to turn right onto West Jemez Road whereas the left lane traffic would continue straight. This is about 128 m before the Jemez Road intersection. Traffic going to East Jemez Road would then use the left turn pocket on the roadway segment from the bridge to the intersection.

Figures 9 and 10 compare the travel time distribution for the travelers from North Diamond to East Pajarito for the 3-lane northside and southside merge and for the current 4-lane configuration. Numerous travelers on this path have extremely long travel times, 10 to 15 minutes, for the 3-lane northside merge. Figure 11 shows a snapshot of the vehicles on the network at 22 minutes into the simulation (7:22 am). Southbound vehicles crossing the Los Alamos Canyon bridge form a queue that backs up to the North Diamond "parking location."

Figure 12 shows that the other paths are mostly unaffected by having the merge on the north side of the Jemez Road intersection. In fact, because much of the North Diamond traffic is backed up on the Los Alamos Canyon bridge and does not interfere on the south side of the intersection, the East Jemez traffic is able to go to East Pajarito slightly quicker.

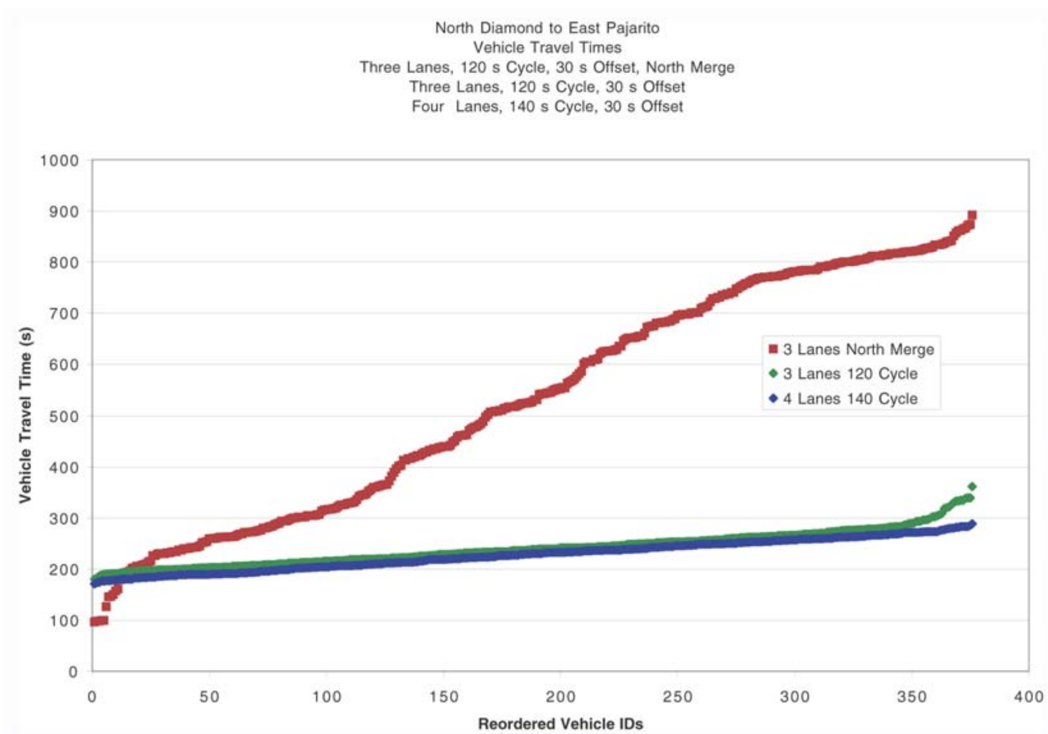


Fig. 9. Travel time distributions for the North Diamond-to-East-Pajarito path for the 4-lane configuration and for the 3-lane configuration merging north of the Jemez Road intersection and merging south of the Jemez Road intersection.

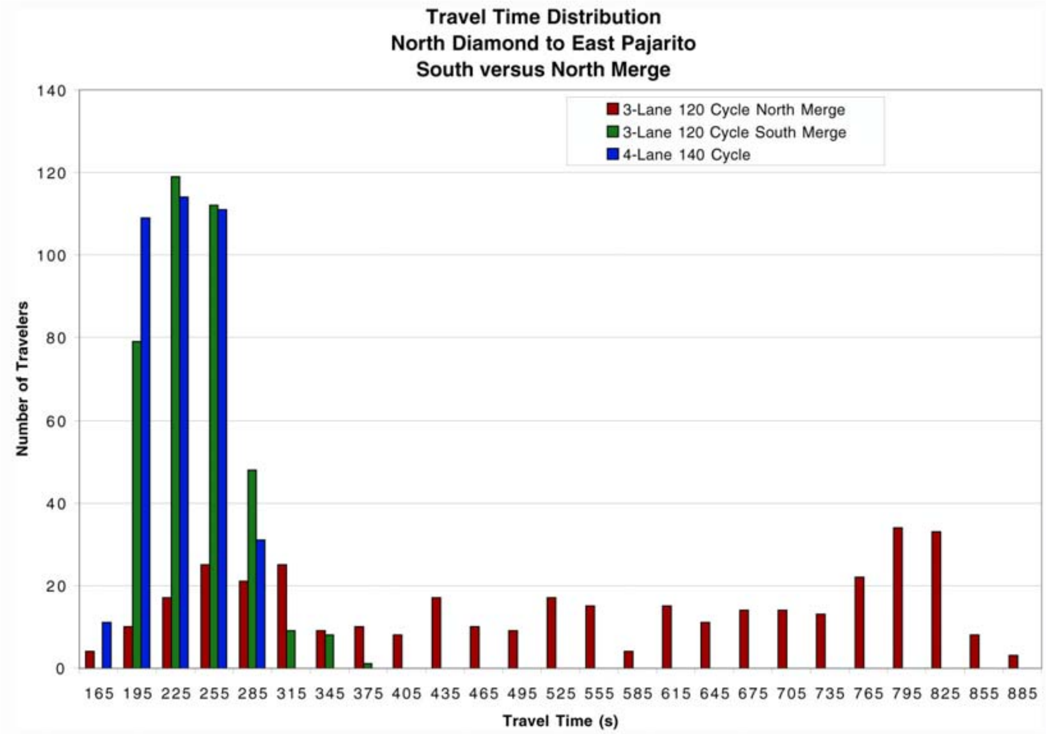


Fig. 10. 30-second histograms of vehicle travel times from North Diamond to East Pajarito for the 4-lane configuration and for the 3-lane configuration merging north of the Jemez Road intersection and merging south of the Jemez Road intersection.

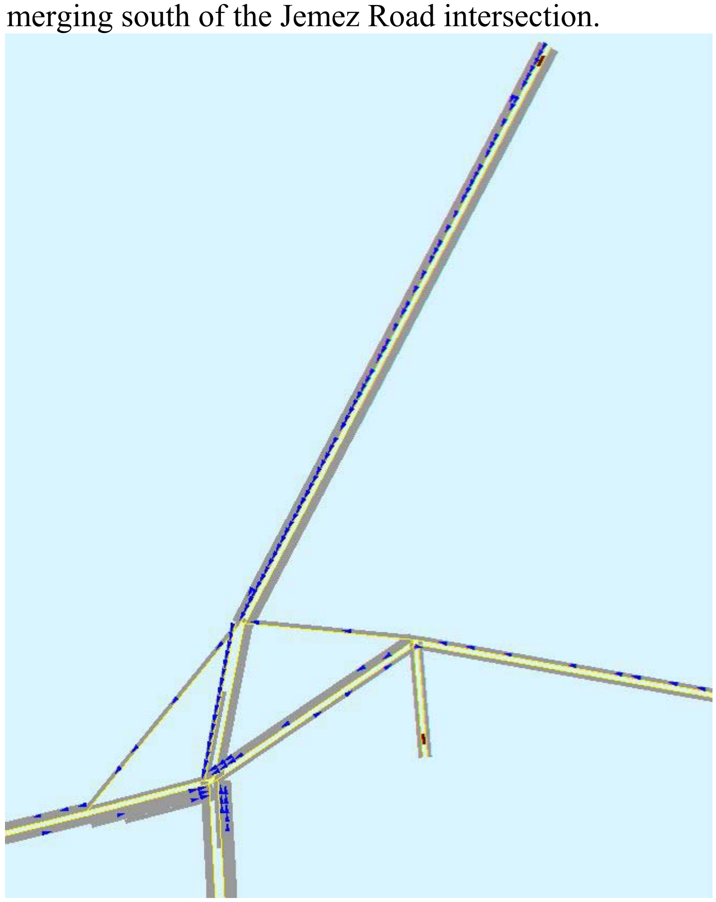


Fig. 11. Snapshot showing backed up traffic for the 3-lane north merge case.

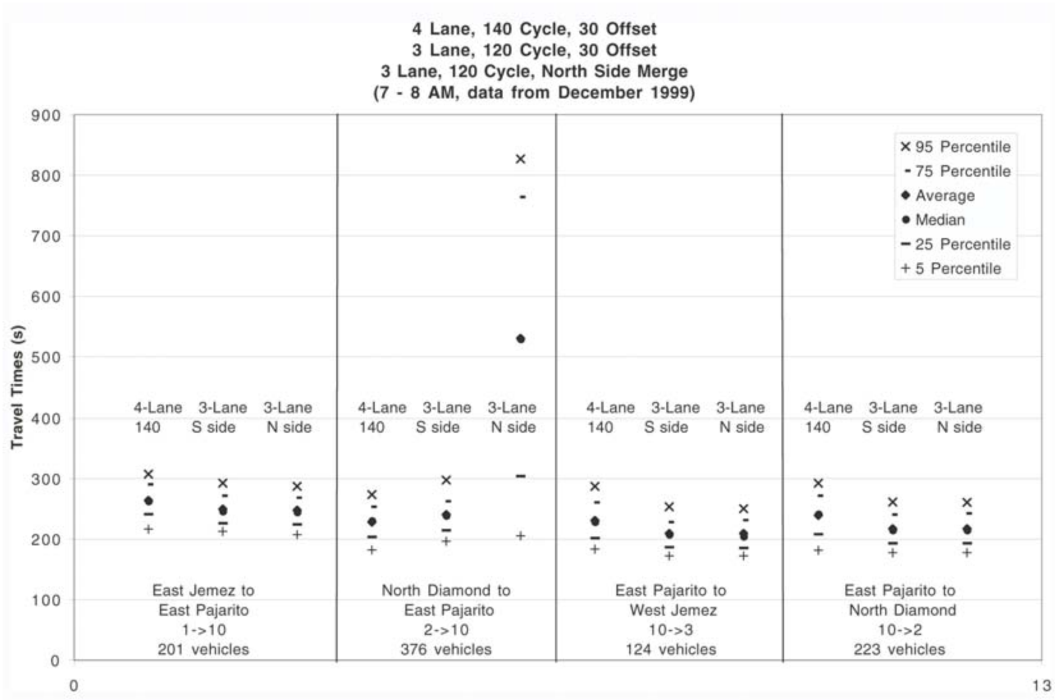


Fig. 12. Averages and percentiles of travel time distributions for the four heavily traveled Diamond Drive paths for the 4-lane configuration and for the 3-lane configuration merging north of the Jemez Road intersection and merging south of the Jemez Road intersection.

The results of the northside merge may have implications to the southside merge. Suppose the 3-lane configuration is implemented with a southside merge. As travelers become familiar with the new configuration, they may begin to anticipate the constriction and merge into the primary single lane well before final merge point. This behavior may lead to long queues across the bridge. It also may lead to some aggressive behavior in the merge region.

XII. Morning Simulation: Increased Traffic Volumes

Because of uncertainties in the turn counts used to derive the origin-destination tables, we were concerned about the performance of the alternatives if there were heavier traffic flow. So we simulated 20% more vehicles during the morning peak period on both the 4-lane configuration and the proposed 3-lane configuration. Those results are shown in Figs. 13 through 17.

Figure 13 and 14 indicate that the 4-lane configuration handles the increased traffic volumes well, but that travelers on the 3-lane configuration would average over 50 seconds slower and a significant number of travelers would take over six minutes to get from North Diamond to East Pajarito.

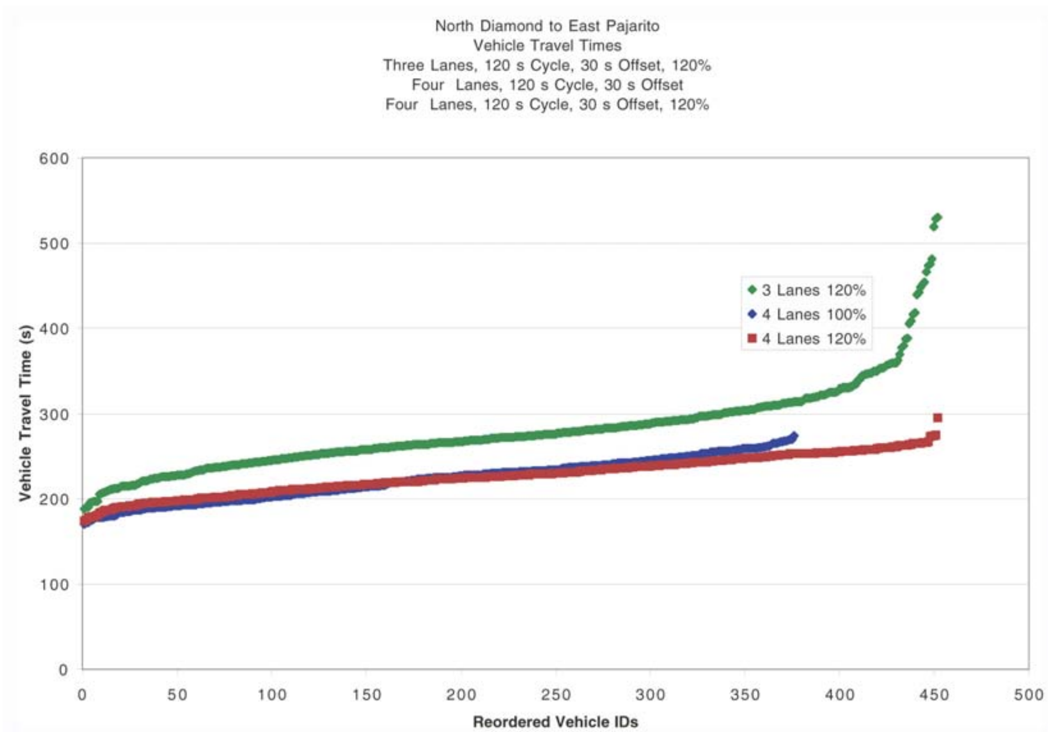


Fig. 13. Comparison of time through the network (2 to 10) for 20% greater traffic in the 3 lane vs 4 lane situation.

Figure 15 shows each individual vehicle travel time plotted at the time that the vehicle reaches its destination, the East Pajarito "parking lot." The vertical bands indicate that the vehicles arrive at their destinations in groups, corresponding well with the signal phases. For the 3-lane configuration, congestion leads to longer travel times as time increases and more vehicles have entered Diamond Drive. After about 40 minutes, there seems to be a slight recovery and then the delays return. At the end of the simulation some of the vehicles caught in the congestion finally reach their destination.

Figure 16 shows that both southbound heavily traveled paths suffer a significant delay with the greater traffic volumes on the 3-lane configuration. Even though the northbound paths also see an increased traffic volume in this case, the total volume in this direction is not great enough to have a noticeable effect on the travel times. The 4-lane configuration can more readily handle the increase in traffic volumes in both directions although there is slight increase in travel times, as would be expected. Those travelers experiencing the long delays would be expected to be the ones complaining to FWO if these increased traffic volumes materialize.

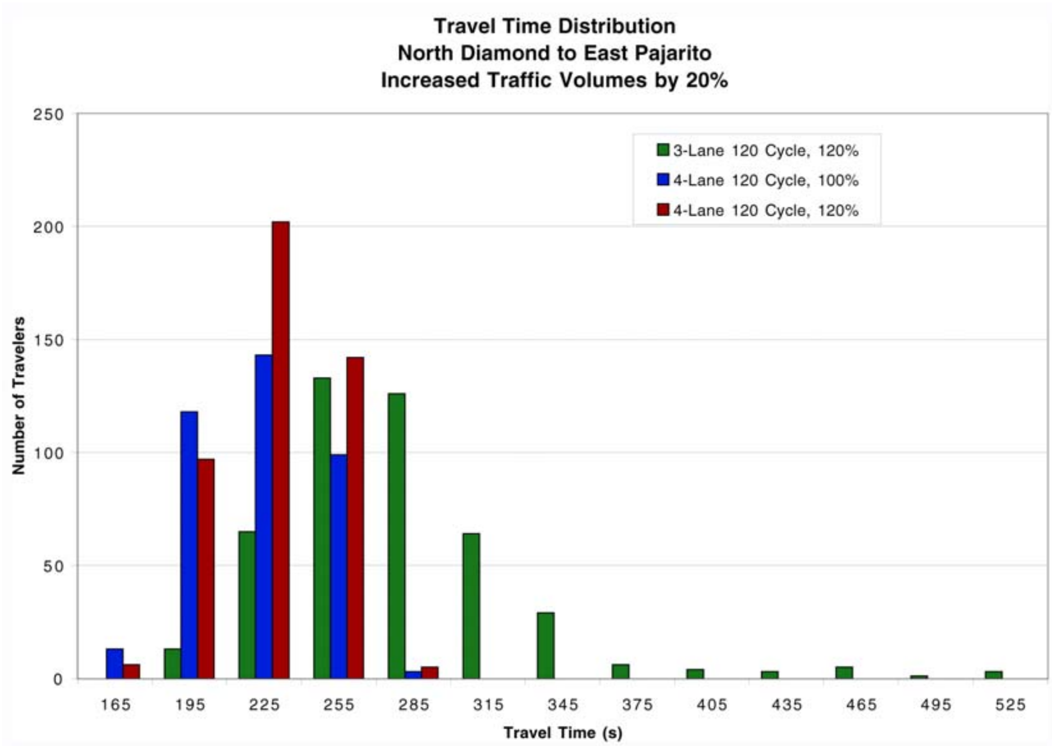


Fig. 14. Distribution of vehicles in each 30 second interval of travel time for a 20% increase in traffic volume.

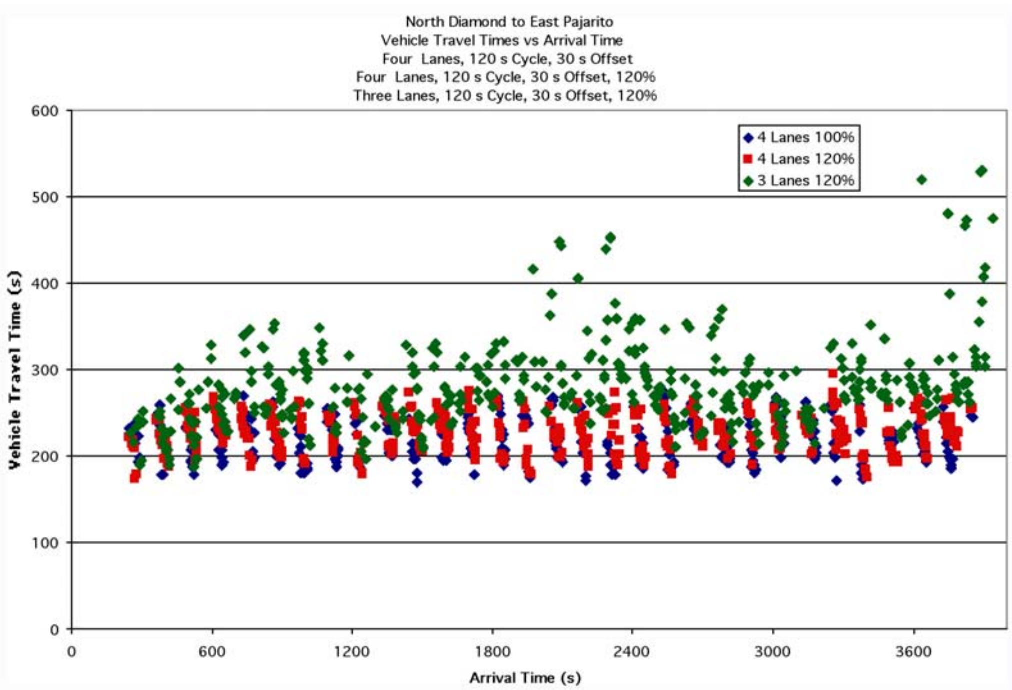


Fig. 15. Vehicle travel times plotted at the time of arrival at the East Pajarito "parking lot" from North Diamond for a 20% increase in traffic volumes.

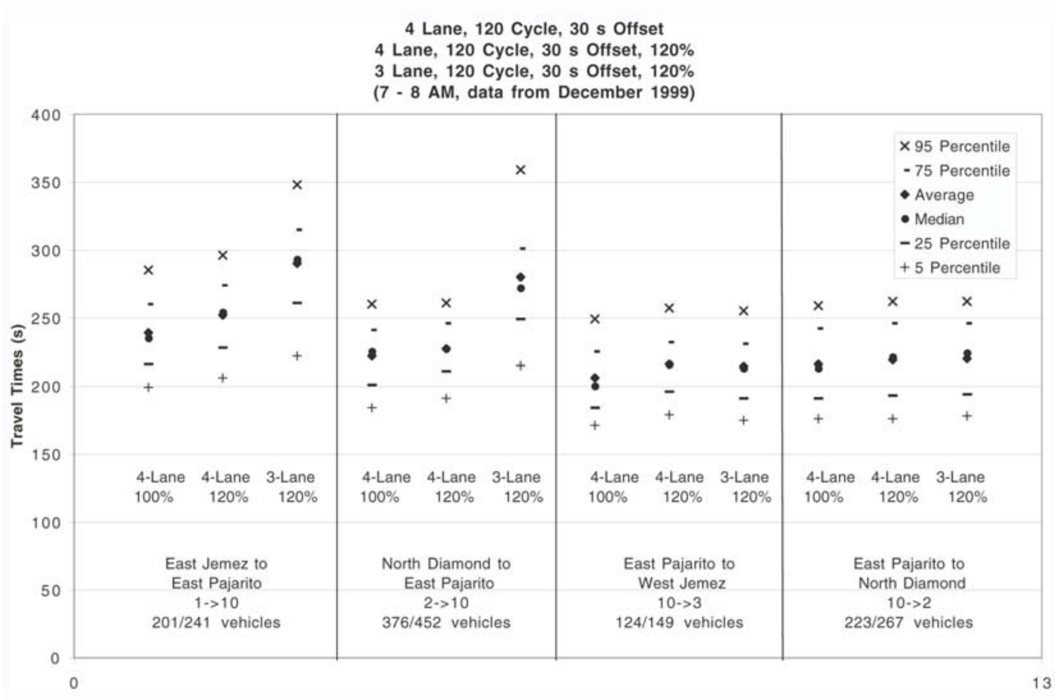


Fig. 16. Averages and percentiles of travel time distributions for the four heavily traveled Diamond Drive paths for the 4-lane 120-second cycle configuration with 100% traffic volume and the 4-lane 120-second cycle and 3-lane 120-second cycle configurations with 120% traffic volume.

XIII. Morning Simulations: Nonuniform Traffic Distributions

The 3-lane configuration's difficulty in handling the 20% increase in traffic volume led us to consider what if the traffic does not load the network uniformly over the one hour simulation period. We had previously set up the simulations to randomly generate vehicle starting times throughout the hour from a uniform (flat) distribution. However, because of work start times, travelers are more likely to arrive in bunches than uniformly.

We considered two additional distributions. Bohannan-Huston had obtained 15-minute-interval traffic counts on the Los Alamos Canyon bridge over 24 hours in each direction. During the morning peak period, the southbound traffic volumes exhibited an approximate 13% higher peak than the uniform distribution. We split the hour into 12-minute intervals to approximate their plotted distribution and generated random vehicle start times that corresponded to this distribution for all the paths. We ran an additional experiment in which the second and fourth 12-minute segment were pulsed with a 37% greater than average traffic volume and the three other segments had corresponding lower traffic. In both cases the total traffic of the one-hour period was the same as for the uniform distribution cases.

The lines at the bottom of Fig. 17 show the three distributions. The uniform distribution is shown in light blue; the 13% peak distribution is shown in reddish purple; and the 37% pulsed distribution is shown in brown. The upper part of Fig. 17 shows the North-Diamond-to-East-Pajarito travel times for the three distributions on the 3-lane configuration as a function of the arrival time of each vehicle at its destination. The travel time distributions for the 13% peak start time distribution and the uniform start time distribution appear to have similar ranges. However, the travel times for the 37% pulsed start time distribution indicate significant delays corresponding to the pulses.

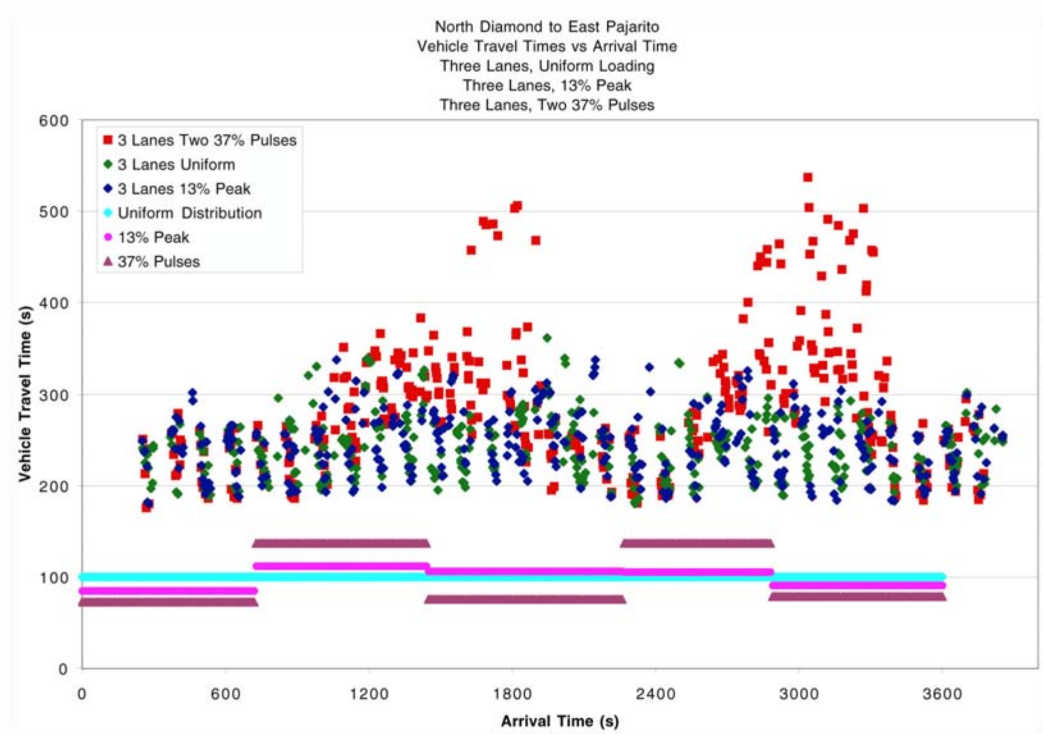


Fig. 17. Vehicle travel times plotted at the time of arrival at the East Pajarito "parking lot" from North Diamond for the three distributions in vehicle start times as shown in the figure.

These observations are supported further in Figs. 18 and 19. The travel times for the 13% peak are slightly longer, although not significantly. For the 37% pulse, the travel times are quite longer, particularly for the higher volume southbound traffic.

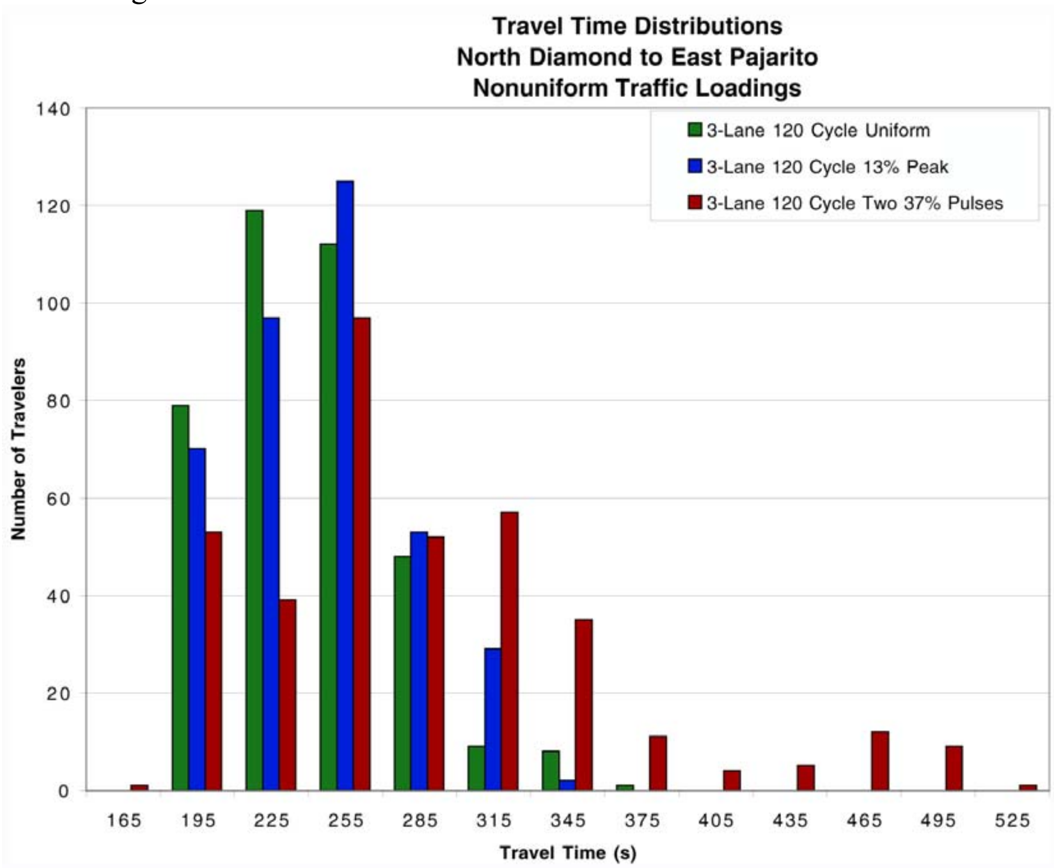


Fig. 18. Nonuniform distribution travel times in 30 sec bins.

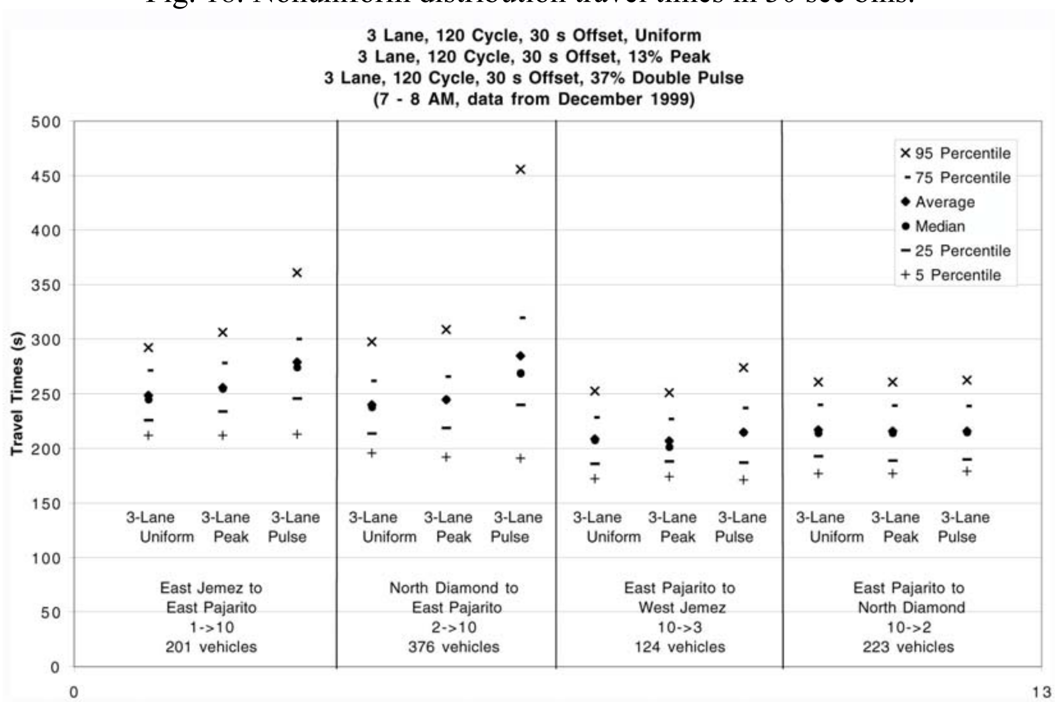


Fig. 19. Comparison of paths for nonuniform distribution.

XIV. Afternoon Simulation: 3 Lane vs 4 Lane

In the morning, traffic converges on Diamond Drive from multiple streets, but primarily North Diamond, East and West Jemez, and East Pajarito Road. North Diamond, in particular, carries two lanes of traffic onto the Laboratory portion of Diamond Drive. The southbound traffic diminishes as vehicles exit into the Eniwetok, Sigma, and other parking locations until those vehicles going to East Pajarito must merge for the left turn at the Pajarito tee intersection. The 3 lane configuration forces the merge to occur earlier with a greater number of vehicles.

In the afternoon, Diamond Drive on the Laboratory property acts more as a feeder for traffic leaving the technical sites. The heaviest volumes are from the East Pajarito single lane to North Diamond and East Jemez. While the current 4-lane configuration allows the northbound traffic to spread out once it gets to Diamond, the single lane still constrains the traffic volume entering Diamond. The 3-lane configuration should have little effect on this traffic flow unless there is significant traffic from the side street "parking locations." However, in the afternoon, traffic is spread out more in time: in keeping with the measured turn counts, we simulated 2928 PM vehicles in an hour instead of 3799 AM vehicles. [Note we did not have time to simulate a "snow day" or evacuation scenario.]

Figure 20 shows the travel times for the three most heavily traveled paths in the afternoon. Note that the signals for the 4-lane configuration were set up originally for a 115-second cycle time, not 140-second. There is a slight preference for one configuration over another depending on which path a traveler is taking, but the afternoon results didn't show a great deal of difference among the cases.

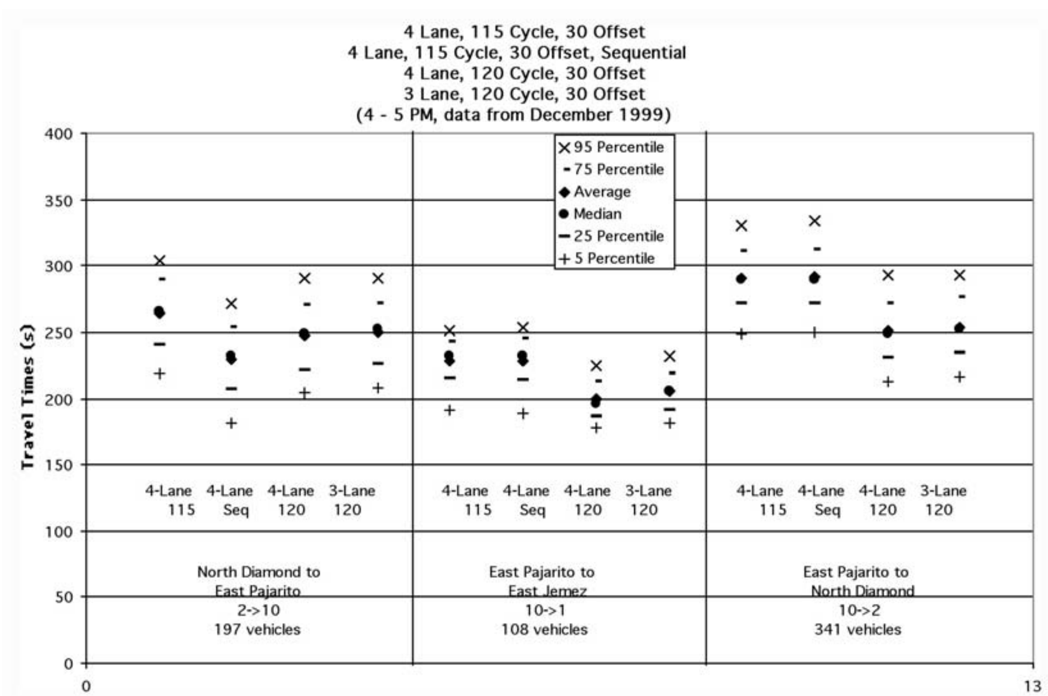


Fig. 20. Comparison of travel times for the 3 lane vs 4 lane in the afternoon peak period (4 to 5 pm).

XV. Discussion

A brief examination of the AM origin-destination table (Table II) and the capacities of the roadways feeding southbound Diamond Drive at the Jemez Road intersection indicates where problems might be expected by converting Diamond Drive to three lanes. In essence, the conversion to three lanes requires that all southbound traffic merge immediately south of the Jemez Road intersection, whereas currently only the through traffic to East Pajarito Road (53% of the total) is required to merge to a single lane at the south end of Diamond Drive. Along the way, the other 47% turn on one side street or another. Of course, there is considerable maneuvering as vehicles attempt to move into proper lanes for turns or slip past vehicles that are turning.

There are some helpful factors. First, traffic from West Jemez onto southbound Diamond Drive is light, accounting for only about 3% of the southbound traffic. Second, about a third of the traffic, that from East Jemez, already is moving as a single lane when it enters southbound Diamond. Furthermore, the Diamond-Jemez intersection signals prevent North Diamond traffic from converging onto southbound Diamond simultaneously with East Jemez traffic. There should be no significant delays caused by the merge to a single lane except for the occasional impatient driver and possible traffic backup from the Eniwetok. The signal phases at Jemez Road allow traffic from West Jemez Road to move prior to the East Jemez Road traffic; this should provide some opportunity to clear up residual merging from North Diamond. Also proper signal phasing at Eniwetok and Sigma should mitigate the backup. The TRANSIMS simulations indicate that there is a slight increase (≈10 seconds) in travel time from East Jemez to East Pajarito and about the same spread in travel time distribution when compared with the current 4-lane configuration.

The primary source of potential problems is the merging of the two southbound Diamond Drive lanes. Sixty-three percent (about 700 vehicles in an hour) of the southbound traffic comes from North Diamond and must funnel in an orderly manner from two lanes to one lane. The TRANSIMS simulations indicate that it is possible to do this with only a slight penalty–a 12-second increase in average time to traverse from North Diamond to East Pajarito. Twelve seconds out of about 240 seconds is likely to be accommodated by most drivers without too much fuss, particularly after they become used to the new driving patterns. However, the TRANSIMS simulations also indicate that about 20% of the Diamond Drive drivers on any given day may incur possibly 20-60 seconds additional delay above the average, and 5% of the drivers may be delayed by more than a minute. Such delays are likely to be annoying to some impatient drivers.

TRANSIMS simulations show that merging north of the Diamond-Jemez intersection would most assuredly be problematic.

The TRANSIMS simulations of alternating north- and southbound flow (sequential signals) at Eniwetok and Sigma for the 4-lane configuration indicate southbound travelers would incur 20-30 seconds longer travel times over the current situation. We made no attempt to optimize the signal phasing so it is possible that these travel times could be reduced.

The turn count data used for these simulations was obtained prior to Laboratory major construction activities that eliminated some parking facilities and altered the traffic flows to use other facilities. There also was a major change in work start times when the Laboratory switched to the 9/80 alternative. This study has accounted for traffic counts taken on the Los Alamos Canyon bridge after this latter change, but not recent turn counts at intersections. We have attempted to include possible effects of some of these changes by simulating higher traffic volumes and different distributions of traveler start times. These simulations also cover uncertainties known to exist in turn count data.

The simulations of higher traffic volumes and different starting time distributions indicate that the three-lane configuration would be operating close to capacity during the AM peak. Perturbations from the baseline volume and uniform distribution are likely to increase southbound travel times for some travelers. The magnitude of the increase is dependent on the perturbation, but some instances could add more than a minute for most travelers and double the usual travel time for some travelers. We did not simulate the effect of incidents whether minor, such as a stalled vehicle, or major, a traffic accident.

Simulations of the PM peak indicate that, under normal circumstances, a three-lane configuration should perform as well as the four-lane configuration. This should not be unexpected. First, PM traffic is spread in time, and therefore the traffic volumes are lower as shown in Table III. Second, Table III also shows that the heavier traffic flows are in the opposite direction, northbound to North Diamond and East Jemez. Southbound Diamond traffic is about a quarter of what it is during the morning peak. Northbound Diamond traffic is about 80% of what the southbound traffic is during the morning peak; about 60% of that comes from East Pajarito. East Pajarito traffic entering Diamond Drive is single-lane traffic so there is no significant merging for the three-lane configuration even though there are a few northbound vehicles from West Pajarito.

The primary delays to northbound PM flow are the signals at Eniwetok and Sigma, but the TRANSIMS simulations indicate that there is little difference between the 3-lane and 4-lane configurations. The TRANSIMS simulations also indicate that the travel times for traffic from Eniwetok and Sigma onto Diamond differ little for the two configurations.

We did not simulate an emergency situation that conceivably would dump more traffic on Diamond in a short time. One can think of some emergency situations in which two lanes in each direction would be advantageous.

In summary, the TRANSIMS simulations show that converting Diamond Drive to 3 lanes on Laboratory property normally should not be burdensome to travelers although some will experience slightly longer travel times than for the current 4-lane configuration. However, during the morning peak traffic, the 3-lane configuration will be operating near capacity, and slight perturbations could cause traffic delays that may stress the most patient drivers.

Appendix A. Files utilized by TRANSIMS.

TRANSIMS reads various tables to actually execute the simulation. For example, the following tables were utilized in this study:

Top-level controlling table:

dflt.cfg . . this table controls specific aspects directly applicable to this simulation, such as time period simulated, paths to input tables, etc.

Input Files:

dia.plan . . plan file telling the simulation each vehicle's path throught the network
dia.vehicles . . tells the simulation where each vehicle starts
dia_output_links* . . the links traveled
dia_output_nodes* . . the nodes traveled
vehicle.prototype . . types of vehicles (e.g., cars, buses, trucks, etc.)

Network Files:

Lane_Connectivity.tbl . . how each lane is connected
Link.tbl . . the links between intersections
Node.tbl . . the connecting points for links
Parking.tbl . . where parking is located
Phasing_Plan.tbl . . allowable paths through signals are defined
Pocket_Lane.tbl . . turn lanes normally
Signal_Coordinator.tbl . . how the signals are coordinated
Signalized_Node.tbl . . listing of nodes that are signalized
Timing_Plan.tbl . . phase timings
Unsignalized_Node.tbl . . listing of nodes that are stop signs, yield, or no control

From the execution of the simulation, various output files are created by choosing various "switches" in the configuration file (top-level controlling table above).

Full details for all these tables and the workings of TRANSIMS can be found through links in the TRANSIMS home page: http://transims.tsasa.lanl.gov.